

Leonardo lecture

Is hydrology a natural science?

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EGU Leonardo Topical Conference "Hydrology and Society", Torino, 14-16 November 2012

UNESCO-IHE
INSTITUTE FOR WATER EDUCATION

Introduction

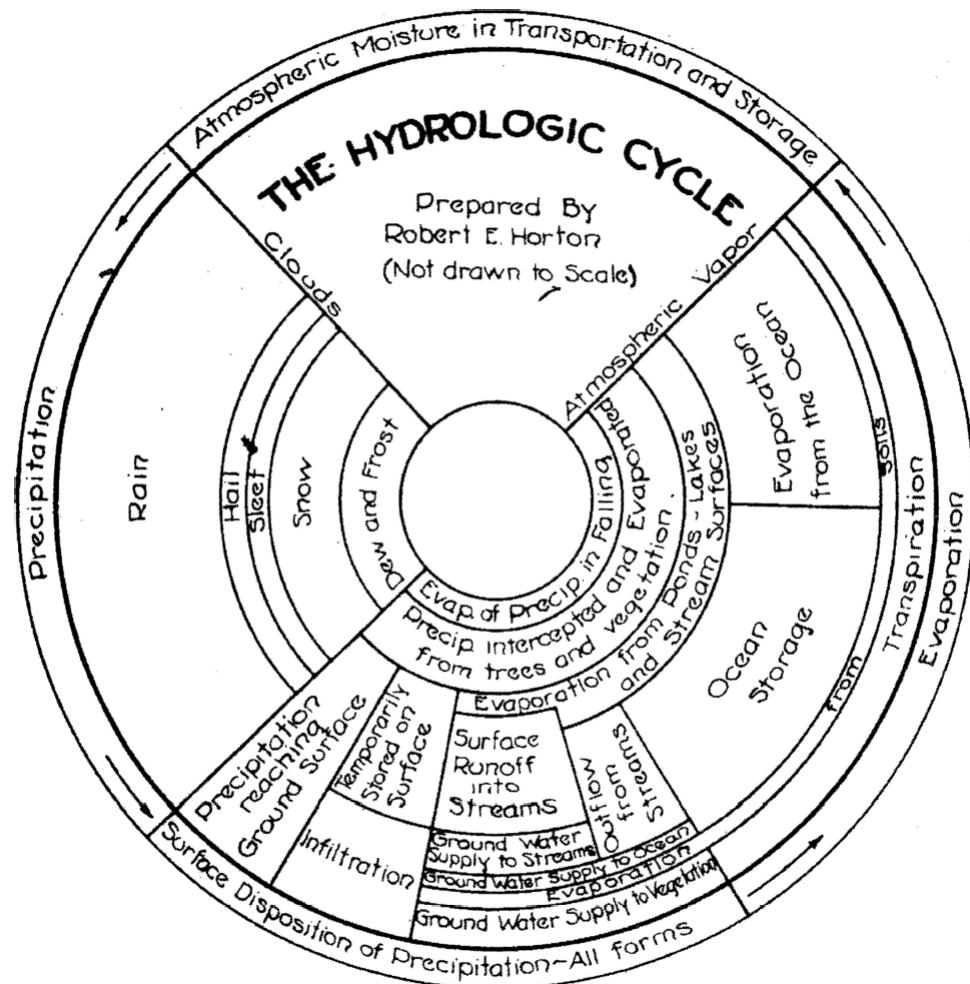
1. Socio-hydrology
2. Hydrology serving and shaping society
3. Coupled human-water systems – Africa
4. Towards a new (reflexive?) hydrology

Is hydrology a natural science?

Defining hydrology

“tracing and explaining the processes and phenomena of the hydrologic cycle, or the course of *natural* circulation of water in, on and over the Earth's surface”

Horton 1931, p. 192,
cited in Linton, 2008, p. 635



1 Socio-hydrology

HYDROLOGICAL PROCESSES

Hydrol. Process. **26**, 1270–1276 (2012)

Published online 24 January 2012 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/hyp.8426

INVITED COMMENTARY



Socio-hydrology: A new science of people and water

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*Humans have changed the way the world works. Now they have to change
the way they think about it, too.* The Economist, May 26, 2011

THE COUPLED HUMAN-WATER SYSTEM

Dateline November 2010, Murrumbidgee River Basin, Australia: Irrigators are up in arms over proposed government plans to cut their water allocations and return flows back to the basin's rivers to support the environment and restore lost biodiversity. *The Australian* of November 04, 2010 reported on the community backlash, including the resort to 'book burning' to highlight their plight. Community backlash and 'book burning' notwithstanding, the reality is that this conflict had been brewing for decades. Now, wind back the clock 100 years to the early 20th century. Up

1 Socio-hydrology

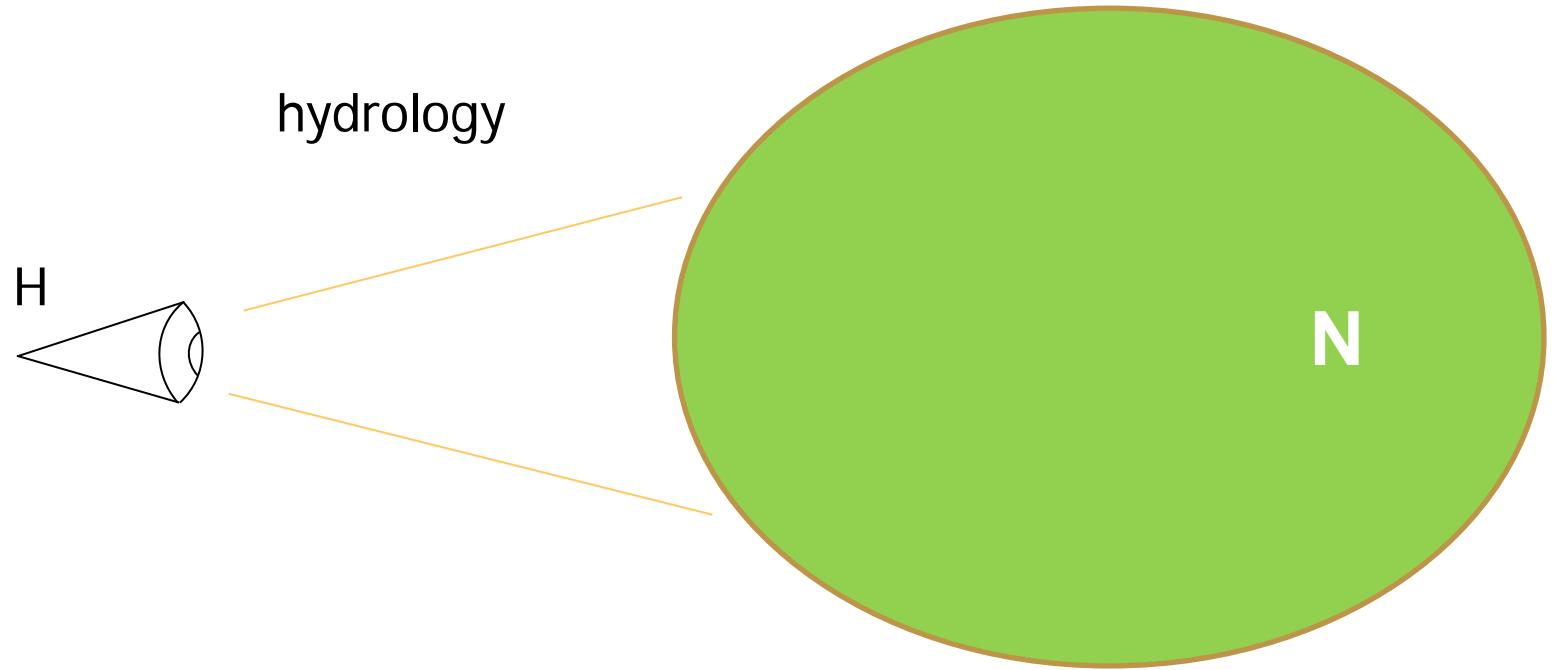
aims at "understanding the dynamics and co-evolution of coupled human-water systems"

"socio-hydrology treats people as endogenous of the water cycle"

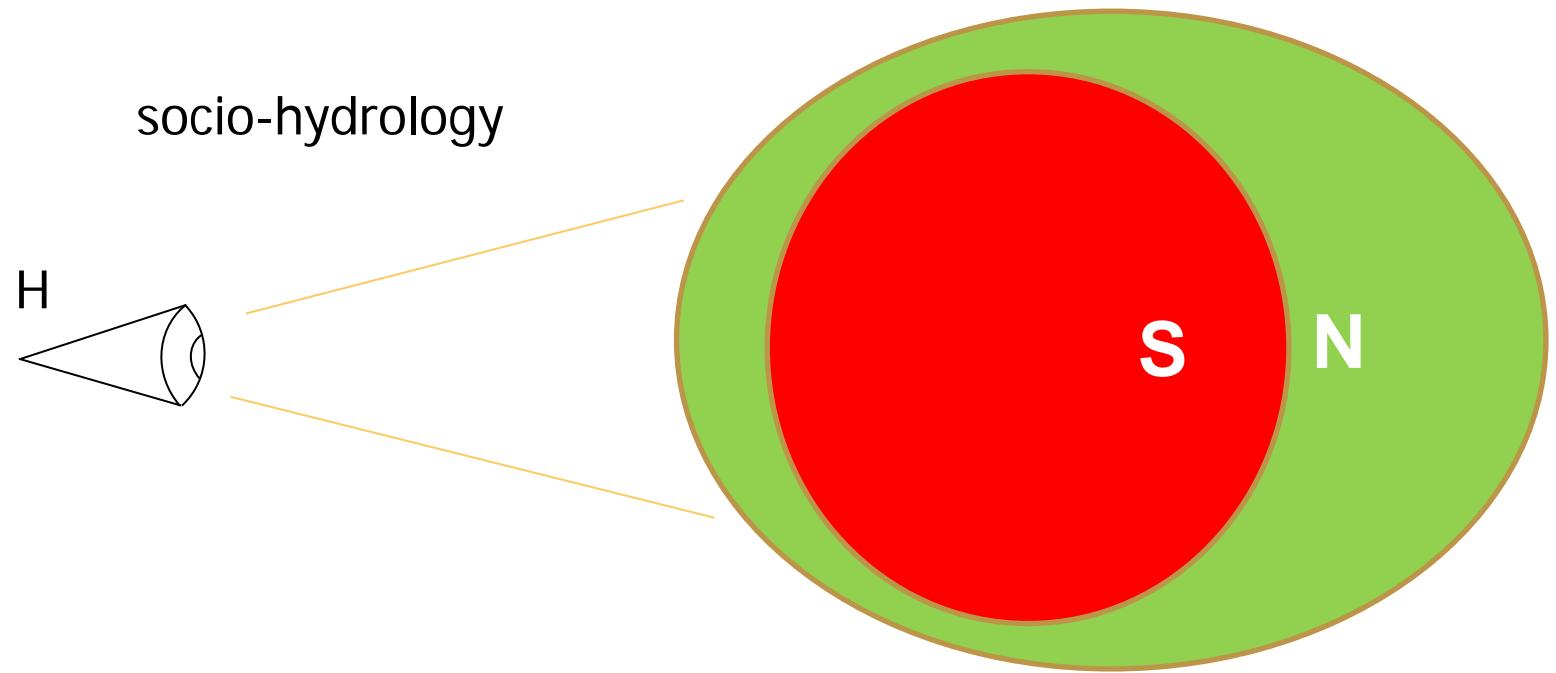
(Sivapalan et al., 2012)

- I find the above propositions interesting but also problematic

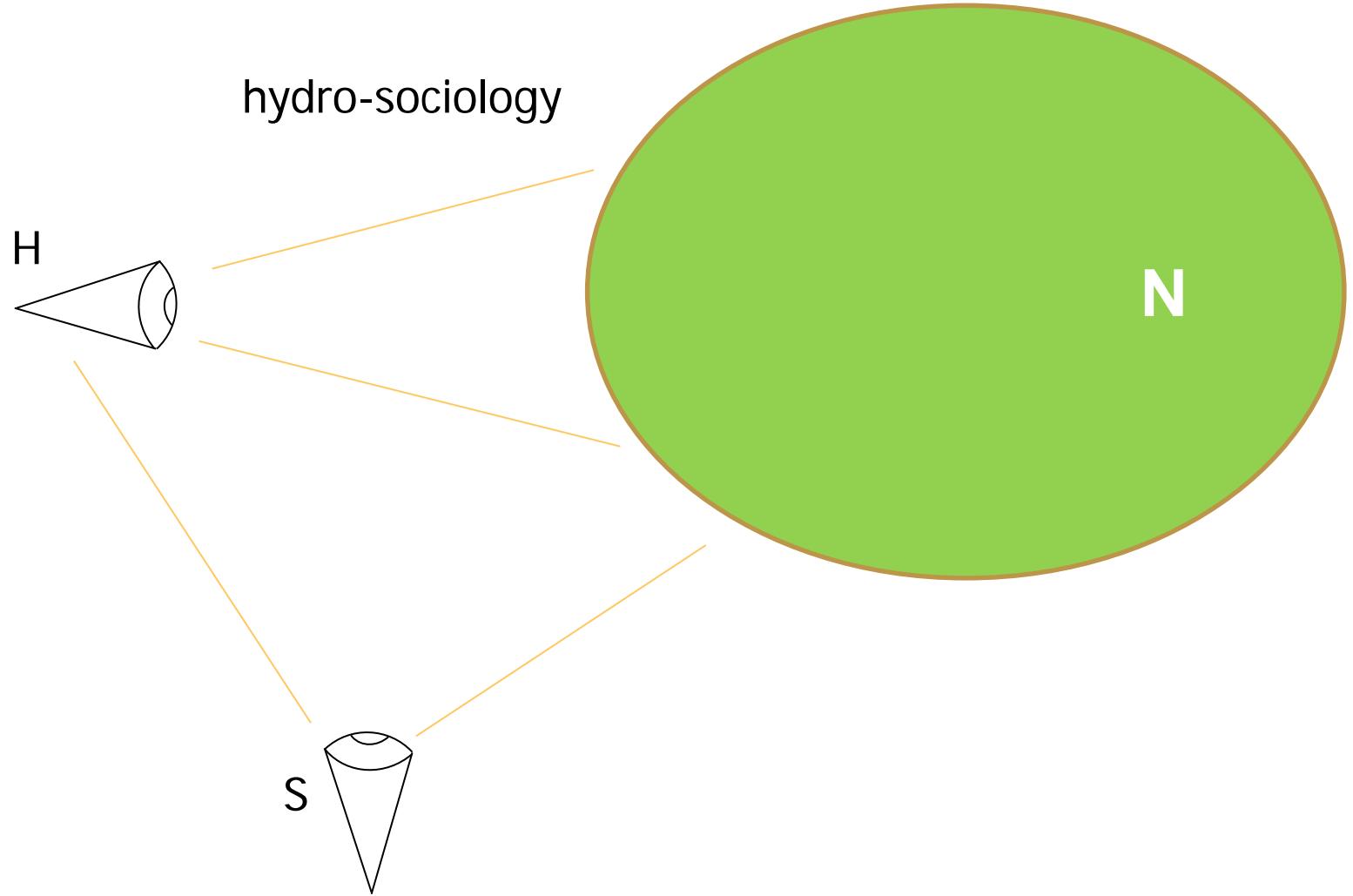
Is hydrology a natural science?



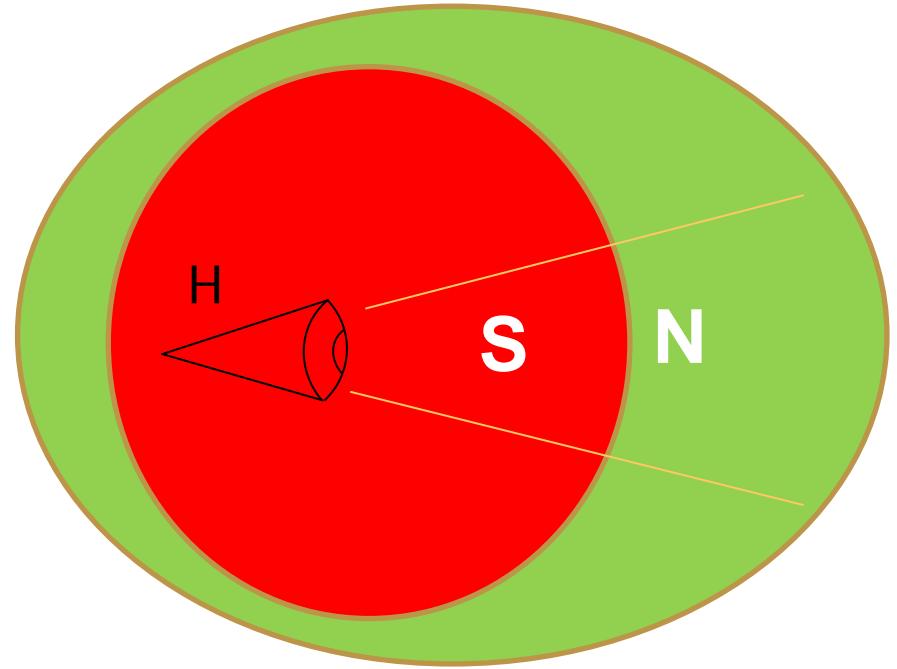
Is hydrology a natural science?



Is hydrology a natural science?



Is hydrology a natural science?



1 Socio-hydrology

aims at "understanding the dynamics and co-evolution of coupled human-water systems"

"socio-hydrology treats people as endogenous of the water cycle"

(Sivapalan et al., 2012)

- I find the above propositions interesting but also problematic
- Seems to imply that hydrology has *not* been integral part of society
- Socio-hydrology should make explicit the role of hydrological knowledge and hydrological consciousness in society.
- Socio-hydrology *vs.* "Hydro-sociology" – how to bring these together
- My own interest: I now see a possibility to contribute to hydrology, as I have studied coupled human-water systems

2 Hydrology serving and shaping society

Nilometer (3000? BC - 1000 AD)

Hero of Alexandria ("the first engineer") (c. 10–70 AD)

Antoine Chézy (1718-1798)

Gaspard Darcy (1803-1858)

S.B. Hooghoudt (1901-1953)

Is hydrology a natural science?

Nilometer (3000? BC - 1000 AD)

These first river gauges were used to plan the start of the irrigation season, and to tax the irrigators.

These Nilometers thus served the status quo.



euratlas.com

Is hydrology a natural science?

Hero of Alexandria ("the first engineer")
(c. 10–70 AD)

measured the discharge of a spring correctly for the first time

this information was important for the design of water works and the supply of water to the city of Alexandria

he also wrote about the discharge of siphons used for irrigating lands bordering the desert

(Biswas, 1970: 87-88)



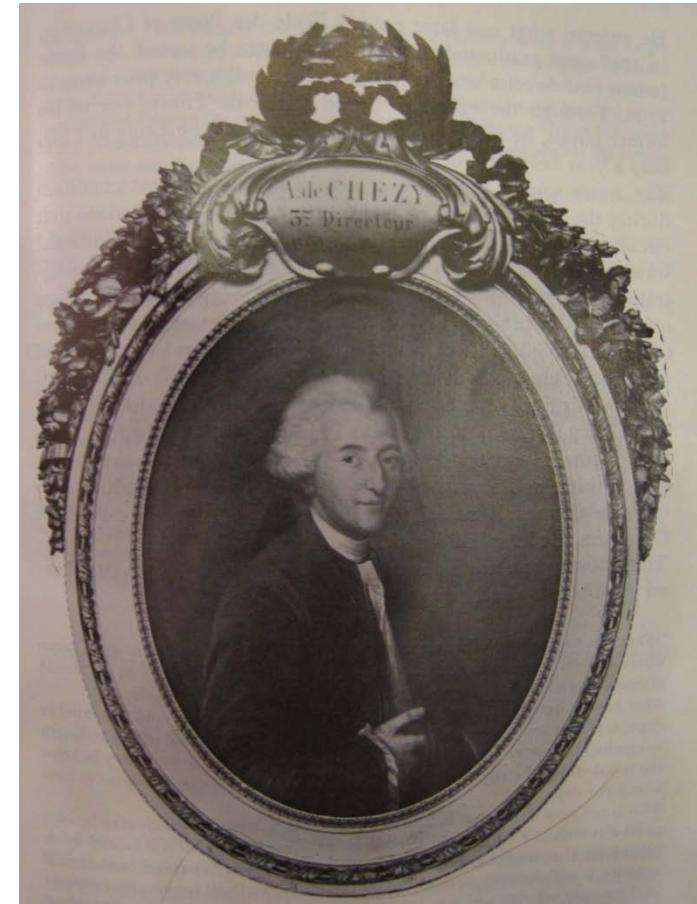
Source: Wikipedia

Is hydrology a natural science?

Antoine Chézy (1718-1798)

needed to design a new canal to bring additional water to Paris, and developed a formula to calculate discharge

(Biswas 1970, p. 262-267)

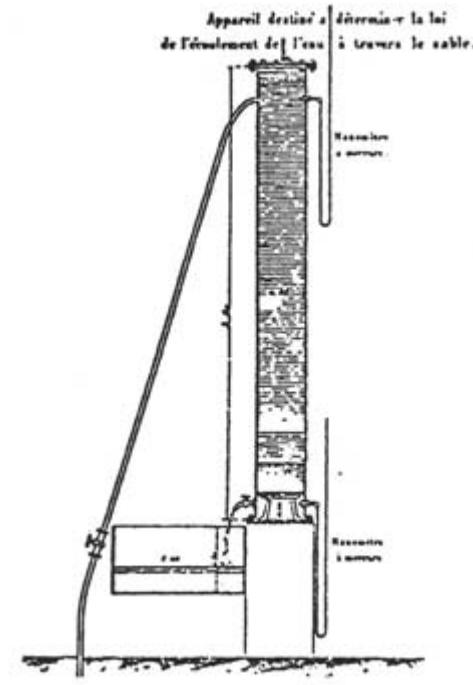


Is hydrology a natural science?

Gaspard Darcy (1803-1858)

in his 1856 report on the water supply system of Dyon described in quantitative terms the purification of water by filtration through sand and developed an equation that is considered the theoretical foundation of groundwater hydrology

(Biswas 1970, p. 308)



Is hydrology a natural science?

The Netherlands

In 1857 the General Royal Agricultural Association in The Netherlands called for a **competition** whereby a reward would be given to the person who could design a sub-surface drainage system for agricultural lands based on scientific rules in the most effective manner.

The absence of an adequate groundwater flow theory that could model Dutch circumstances was considered problematic.

Apparently no satisfactory solution was submitted

(De Vries, 1982: 18-19)

Is hydrology a natural science?

S.B. Hooghoudt (1901-1953)

published in 1940 a formula to calculate the spacing of and size of underground drainage pipes for a two-layered soil profile with different permeability.

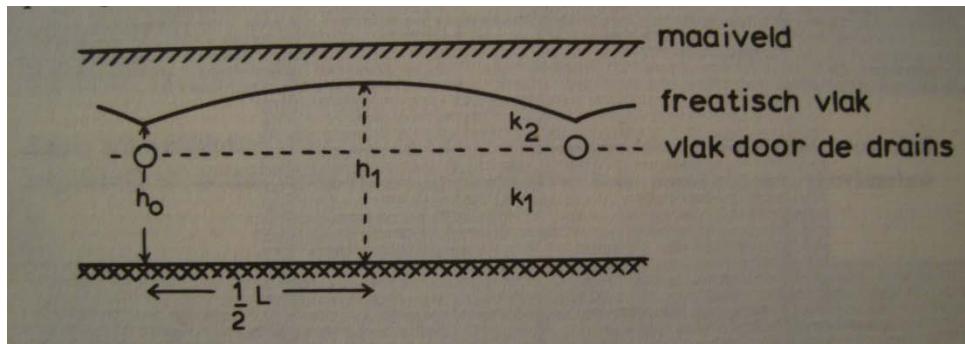
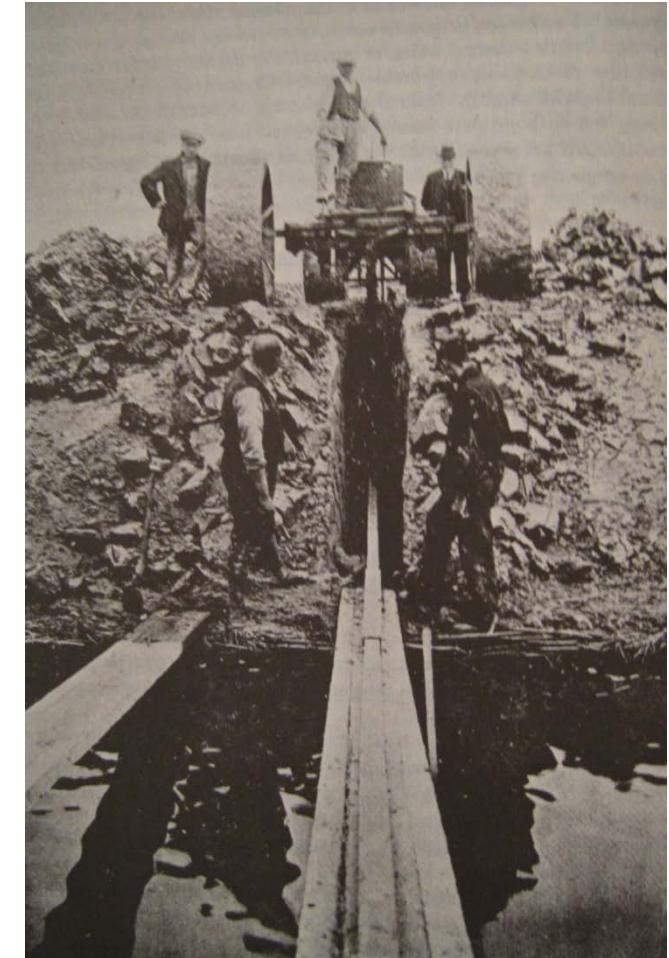


Fig. 32. Dwarsdoorsnede door drains bij een twee-lagen situatie (volgens Hooghoudt 1940).

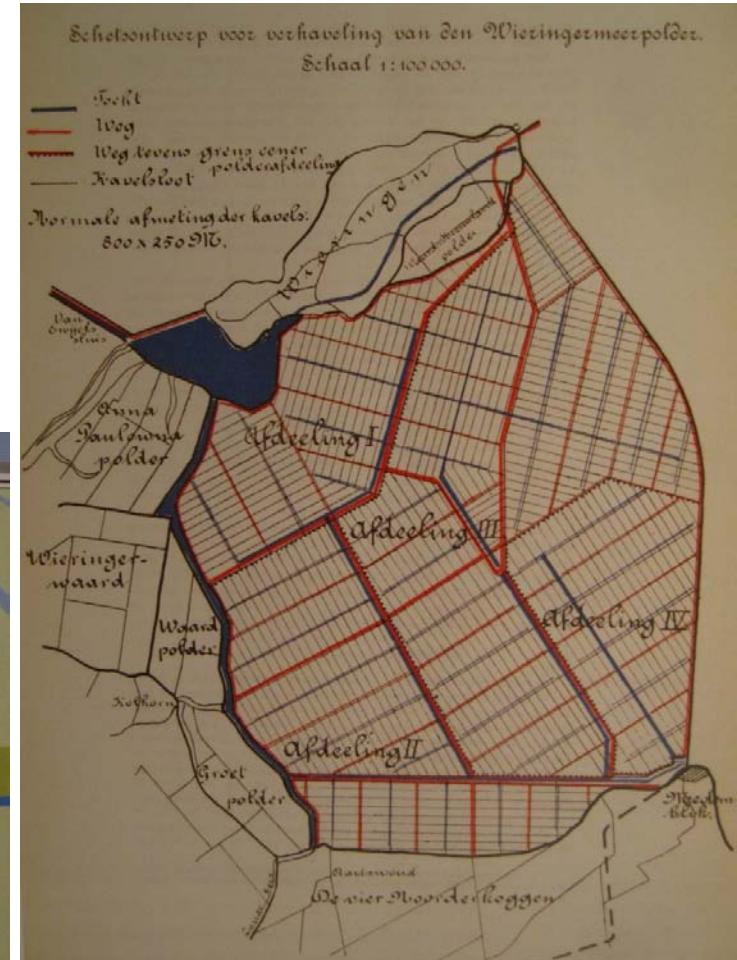
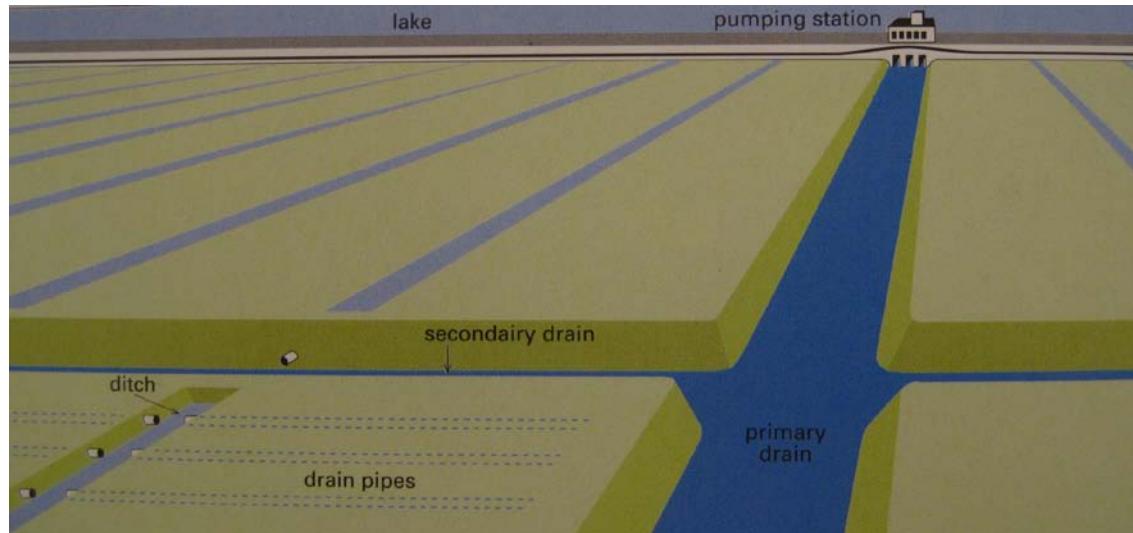
$$NL^2 = 8 k_2 d (h_1 - h_o) + 4 k_1 (h_1^2 - h_o^2)$$



(De Vries, 1982, p. 92 & 86)

Is hydrology a natural science?

S.B. Hooghoudt (1901-1953)



Is hydrology a natural science?

Conclusion: hydrology has been instrumental in shaping society. This knowledge helped to transform the landscape – and thus also the very hydrology it had helped to describe and analyse

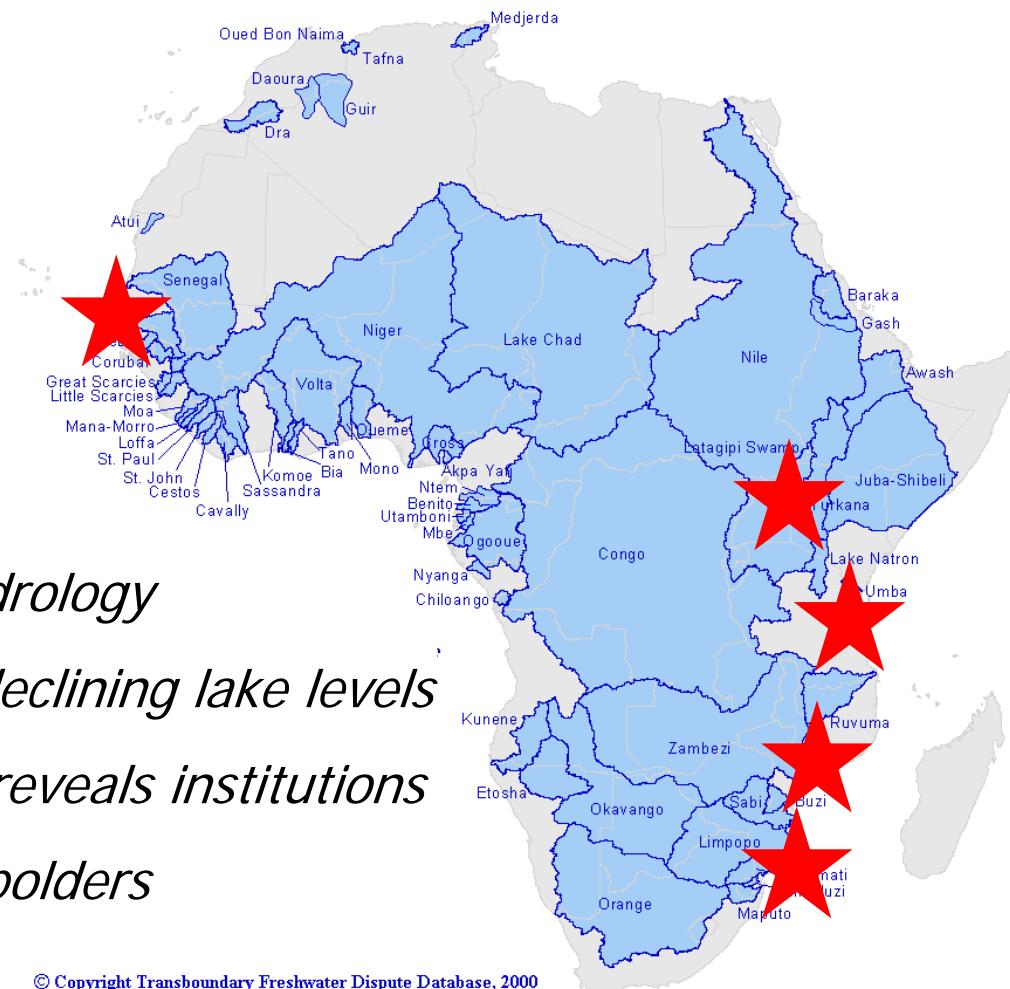
The history of hydrological research describes
"how the human "art" calls upon "nature", which it has violated, for assistance to mitigate the consequences"
(R. Hooykaas in De Vries, 1982, p.ii)

This in fact describes an active process of co-evolution between society and hydrology

3 Coupled human-water systems - Africa

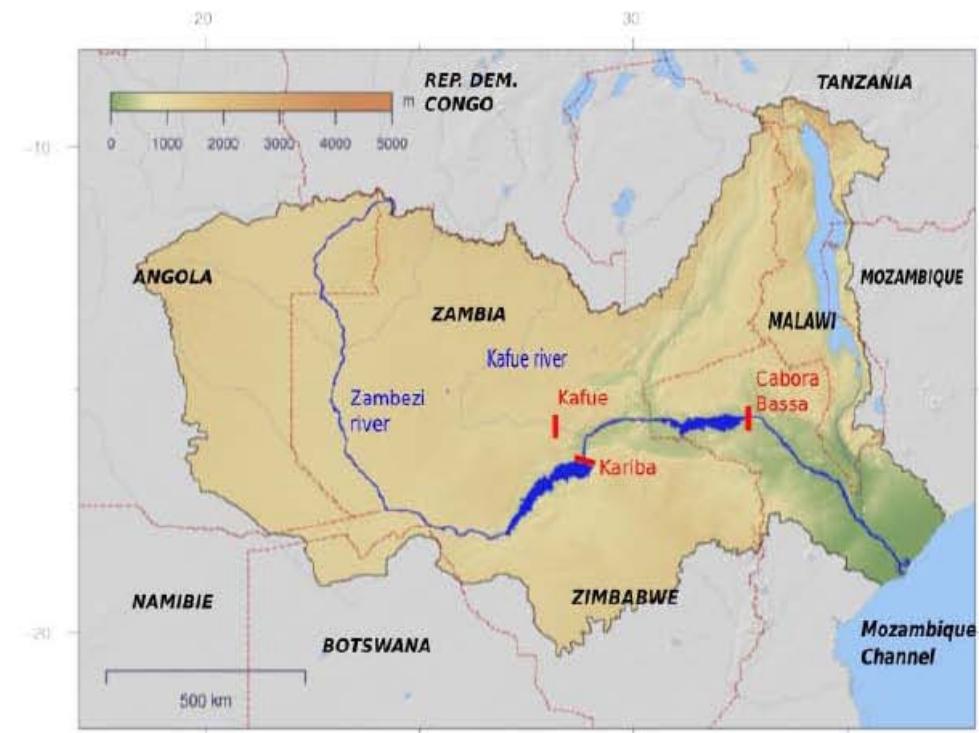
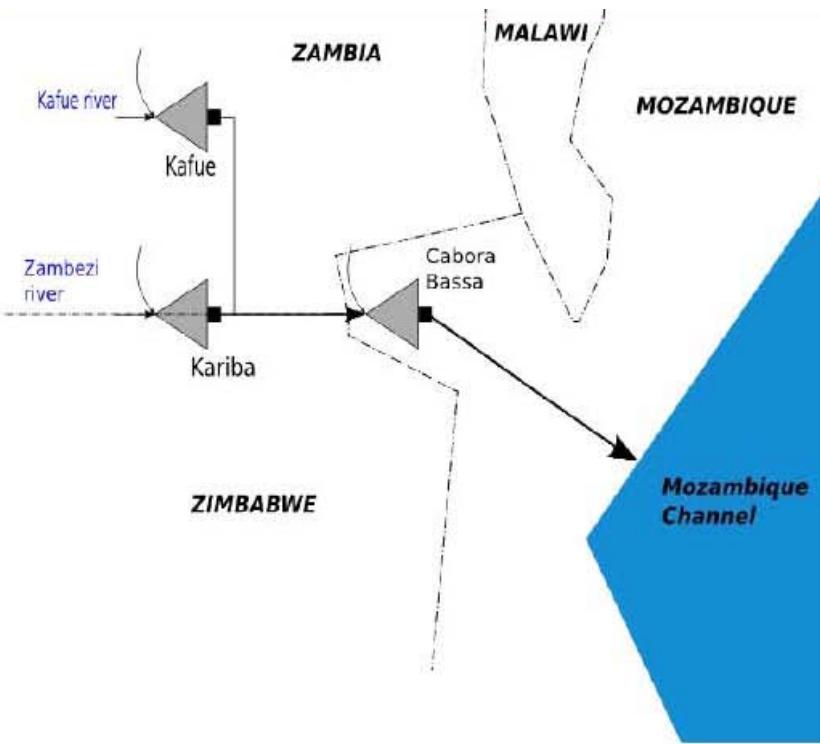
Coupled human-water system have fundamentally changed the hydrology, even in Africa!

- Zambezi: *a modified flow regime*
- Incomati: *what is the natural hydrology*
- Lake Victoria: *controversy over declining lake levels*
- Makanya, Tanzania: *hydrograph reveals institutions*
- Basse Casamance, Senegal: *ricepolders*



Is hydrology a natural science?

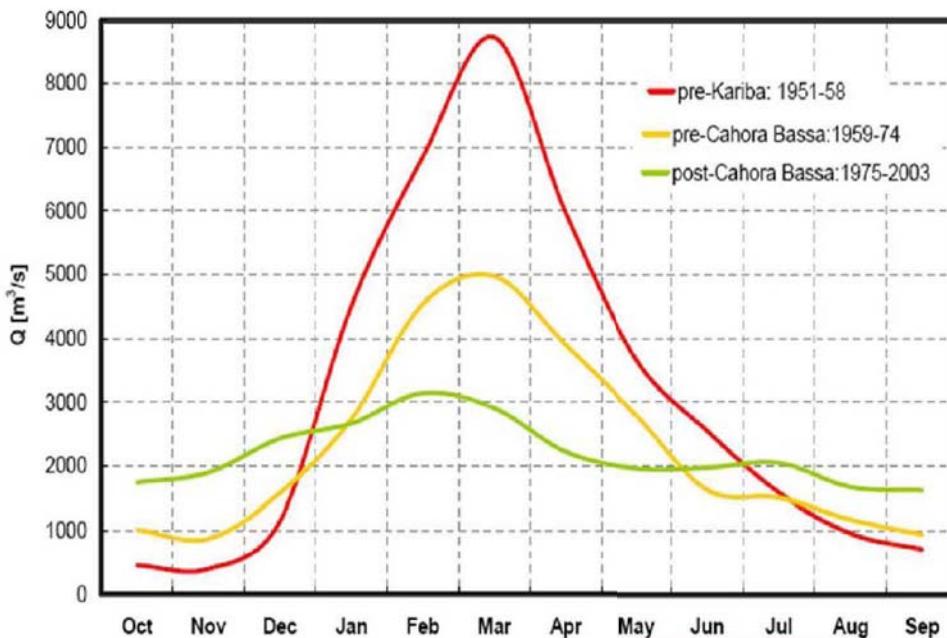
Zambezi



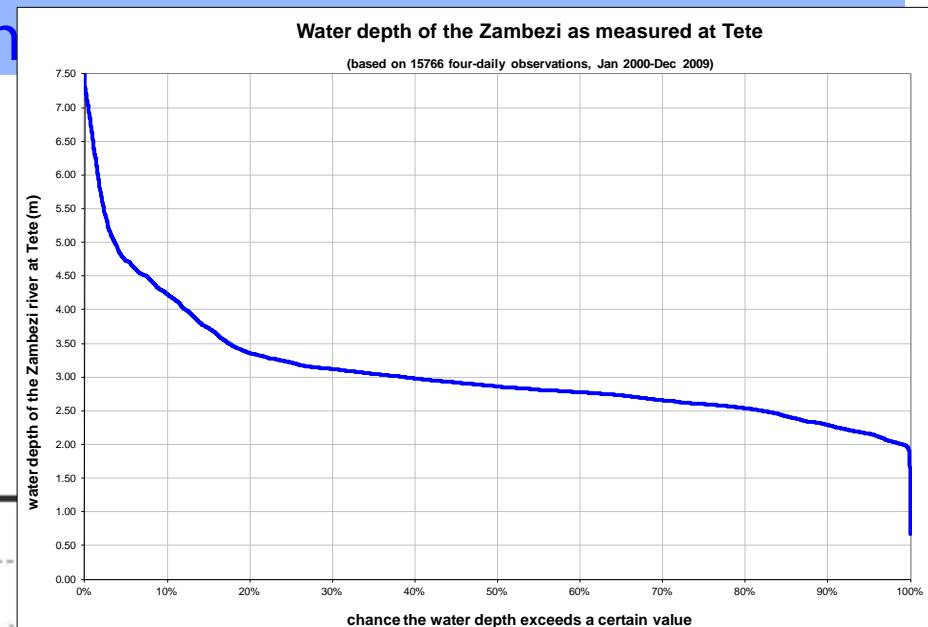
Is hydrology a natural science?

Zambezi

A completely modified flow regime

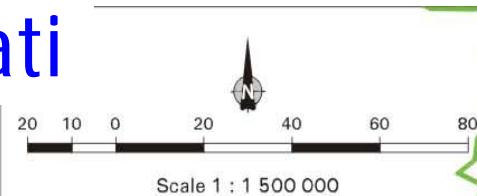


Monthly average discharge at Tete, Mozambique (Source: Ronco et al., 2010)



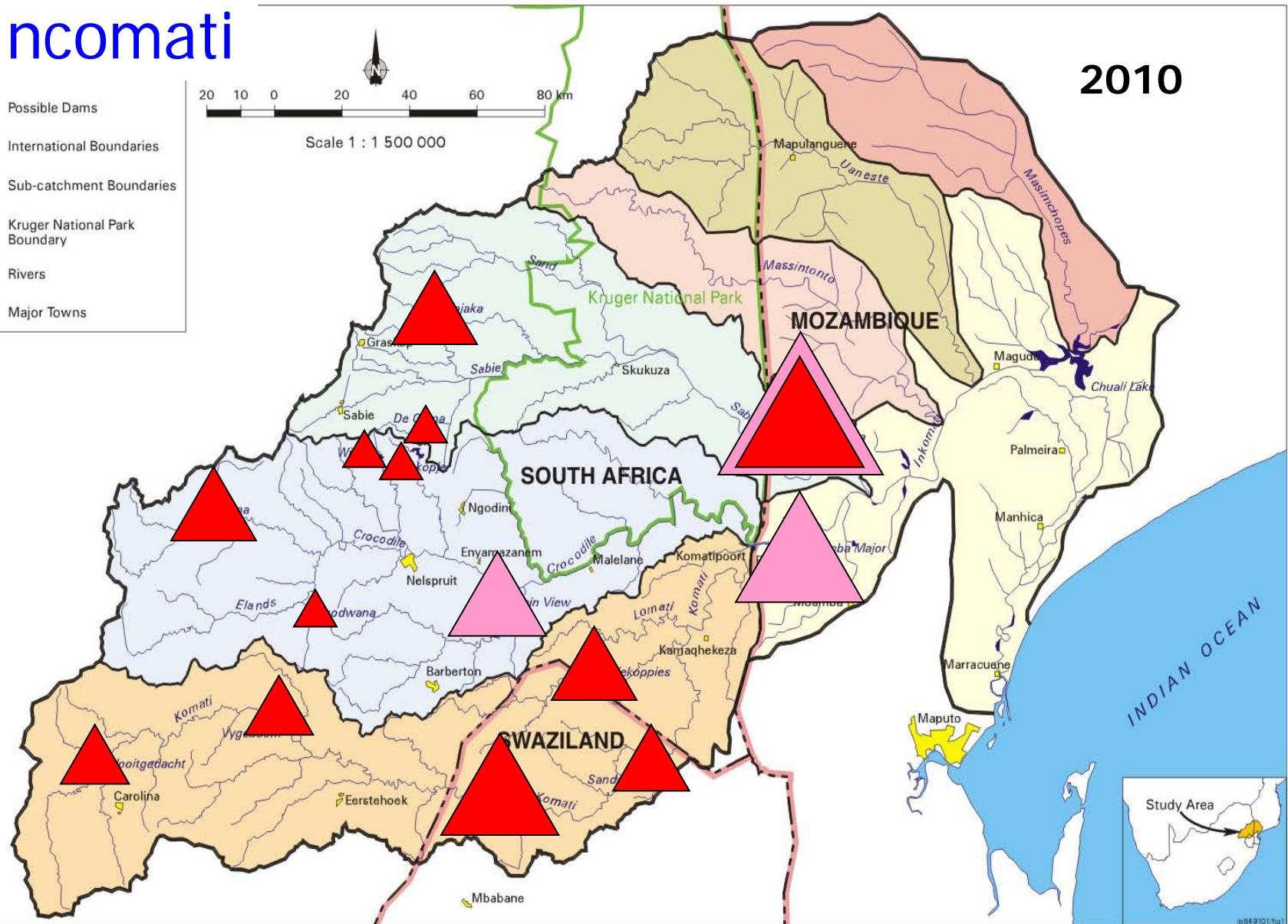
Is hydrology a natural science?

Incomati



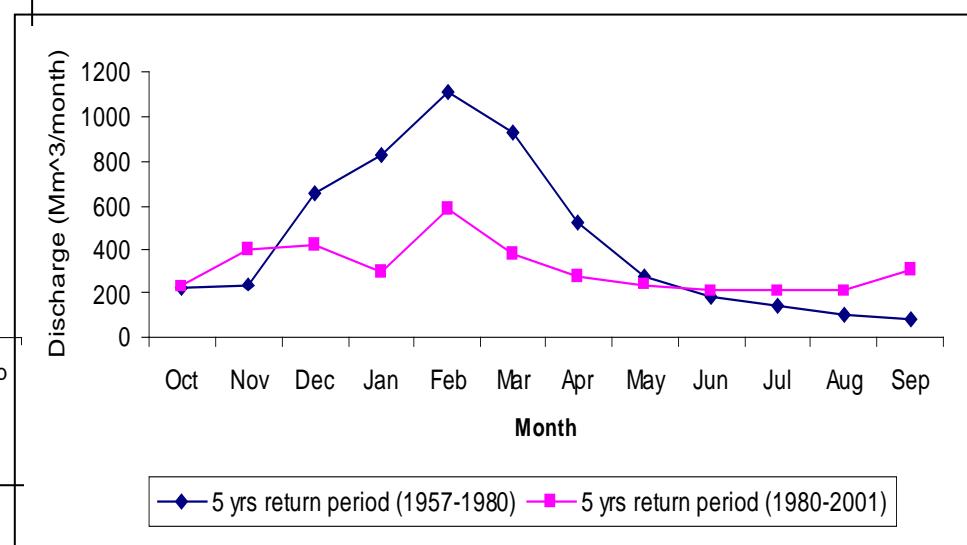
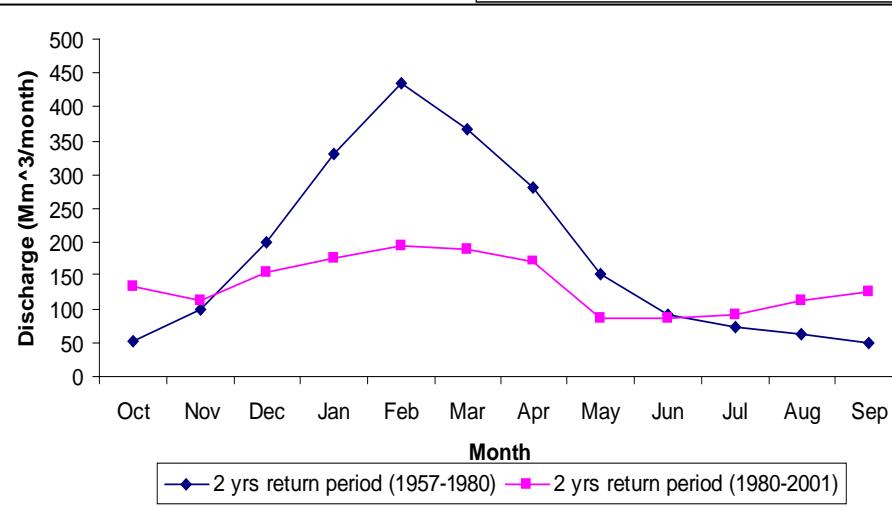
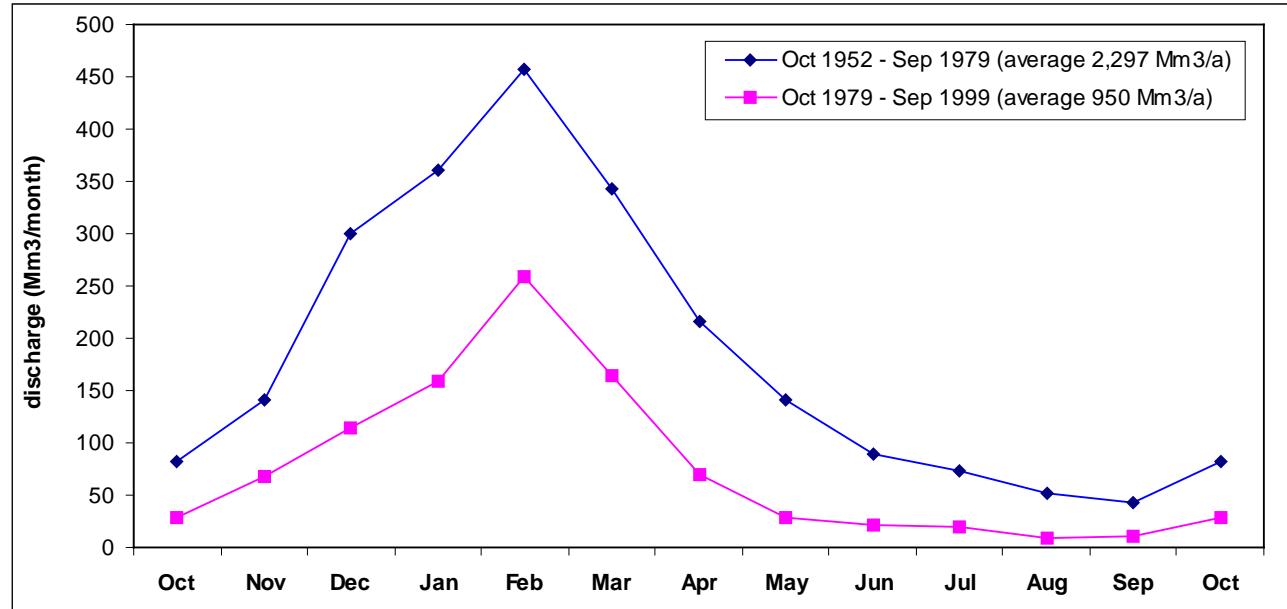
- Possible Dams
- International Boundaries
- Sub-catchment Boundaries
- Kruger National Park Boundary
- Rivers
- Major Towns

2010



Is hydrology a natural science?

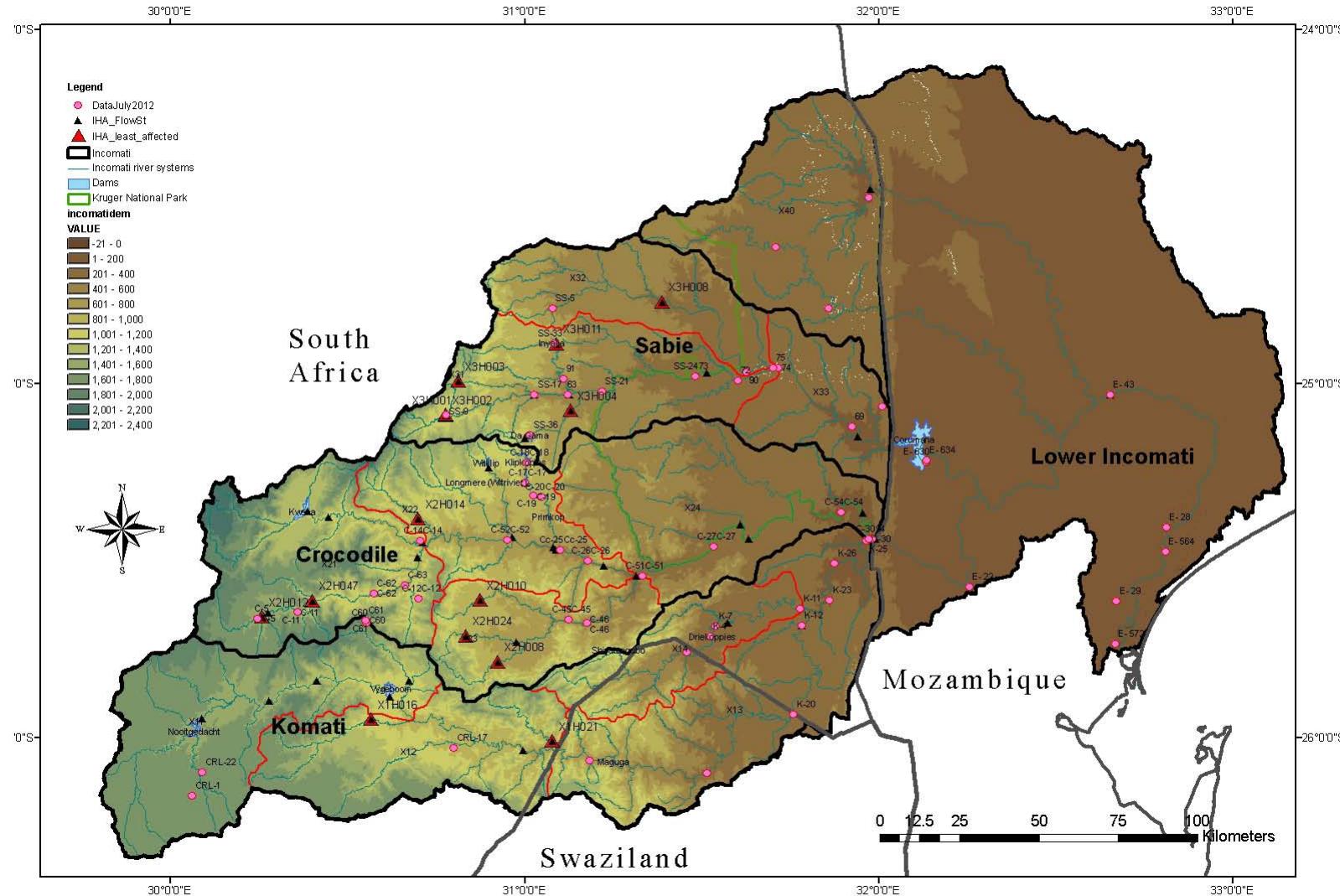
Incomati



Is hydrology a natural science?

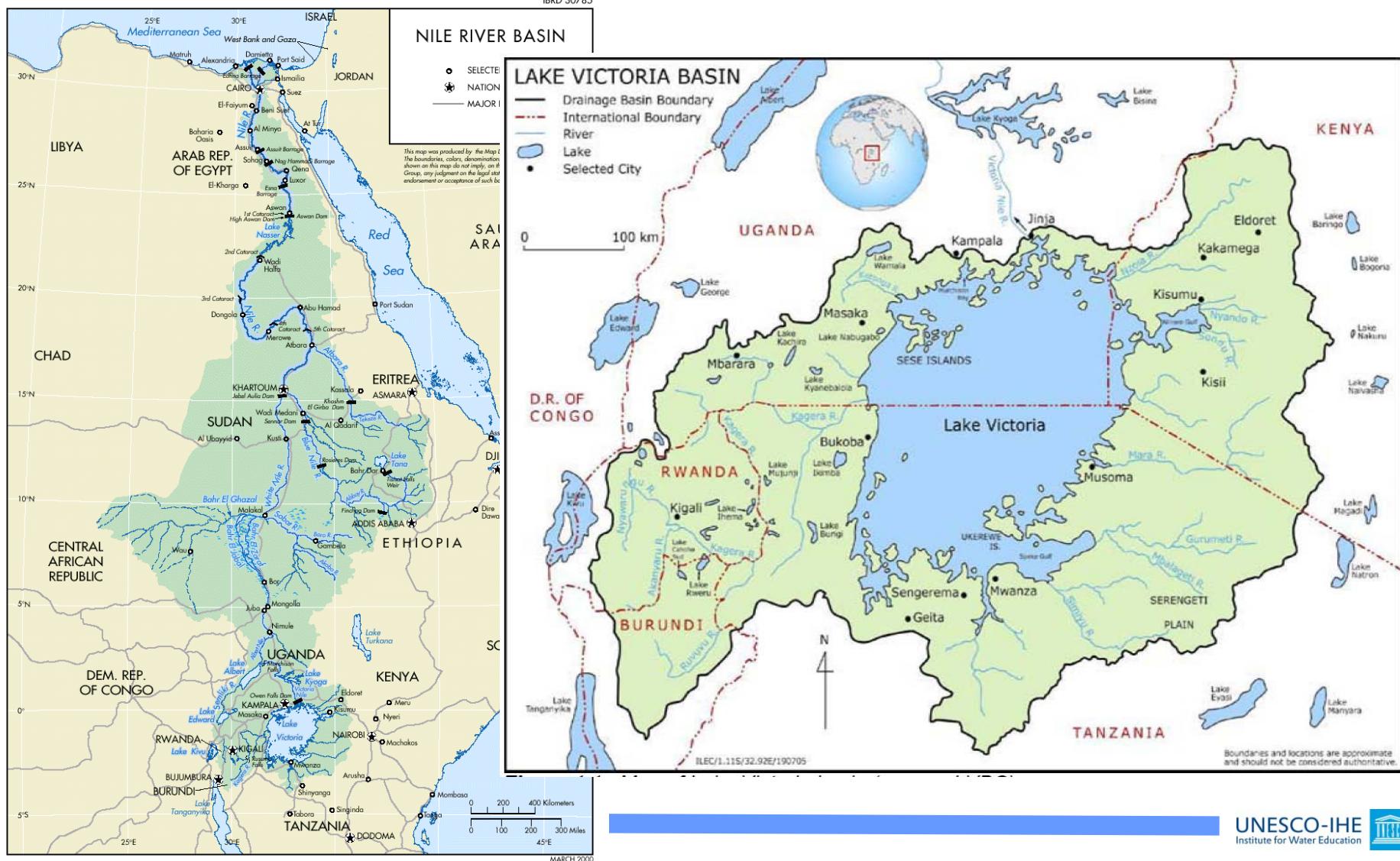
Incomati

What is the natural hydrology?



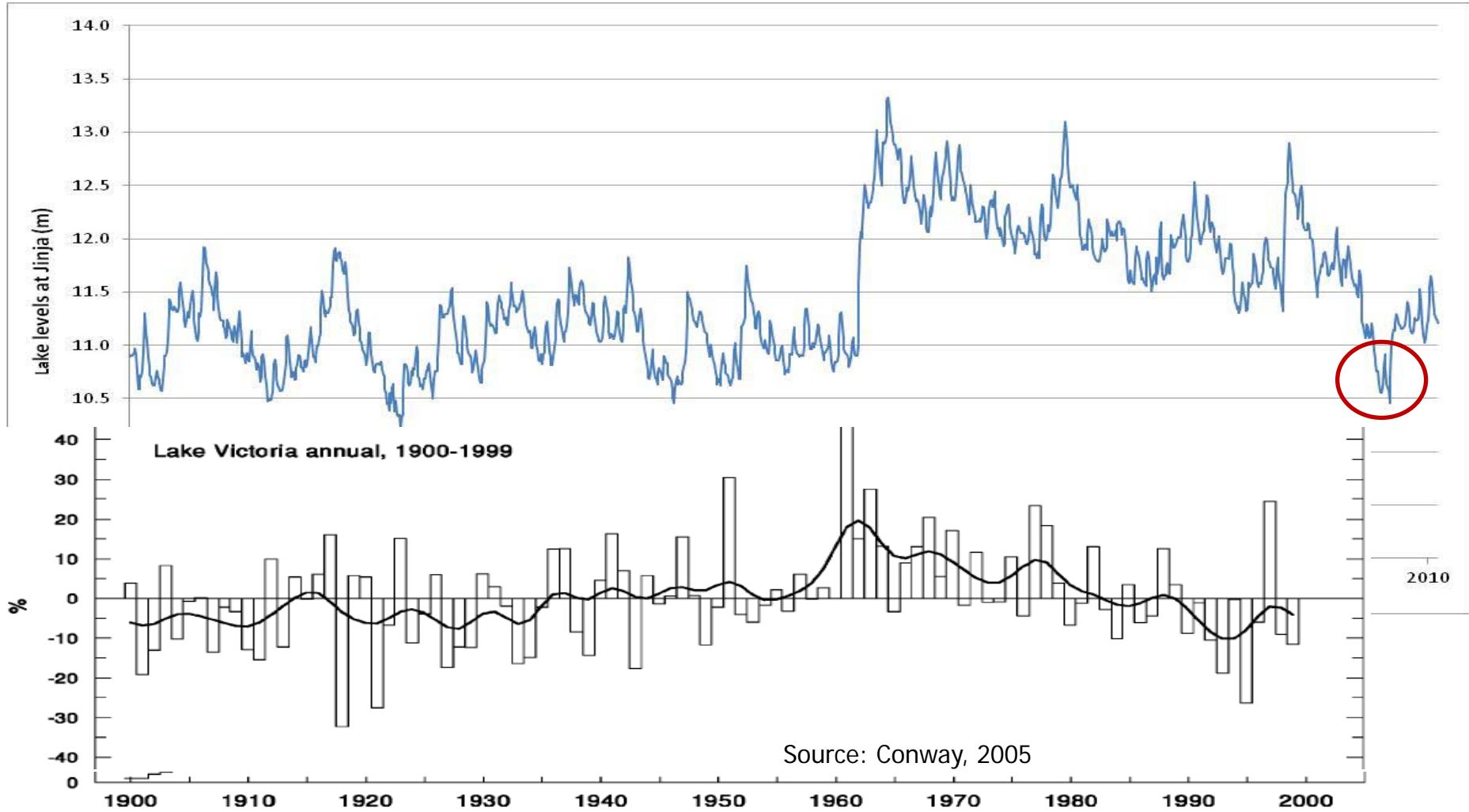
Is hydrology a natural science?

Lake Victoria



Is hydrology a natural science?

Lake Victoria

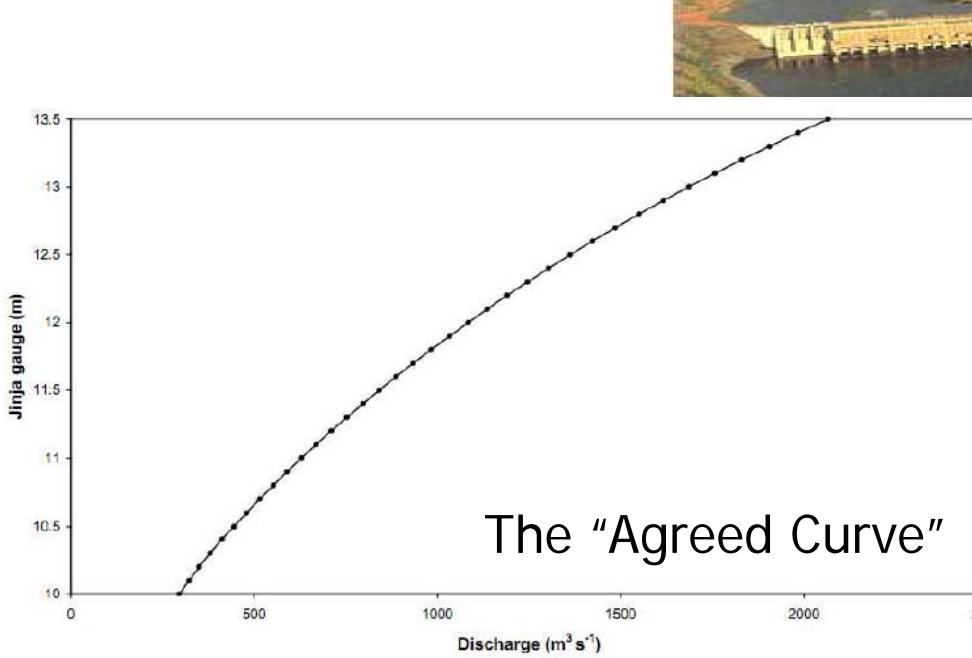


Is hydrology a natural science?

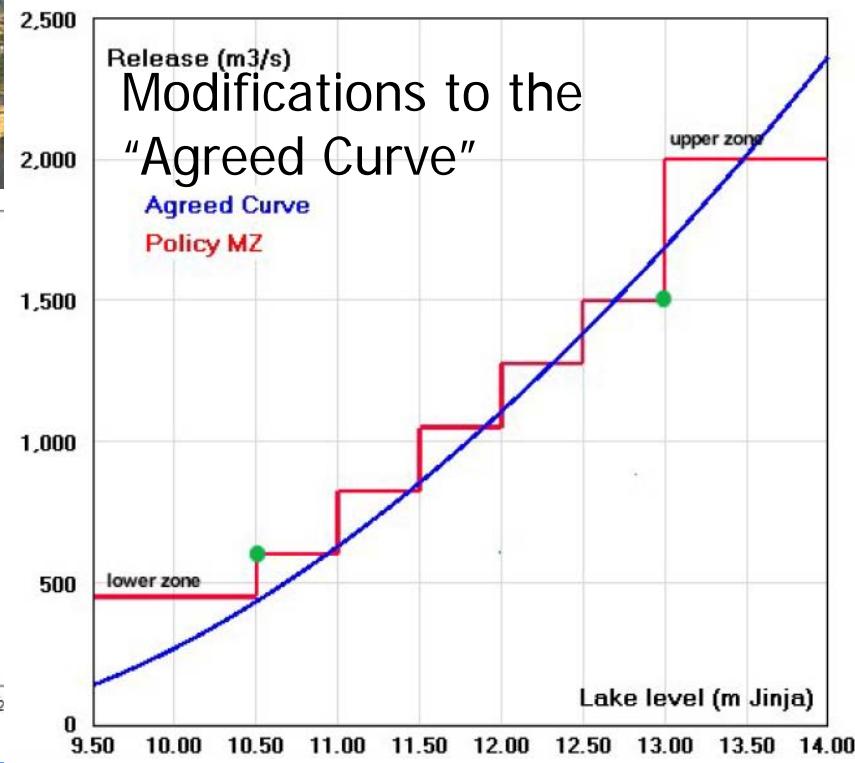
Lake Victoria

Owen Falls (Nalubaale) Dam (1954; 200 MW)

Kiira Dam
(2000; 180 MW)



(Source: Sutcliffe and Petersen, 2007)



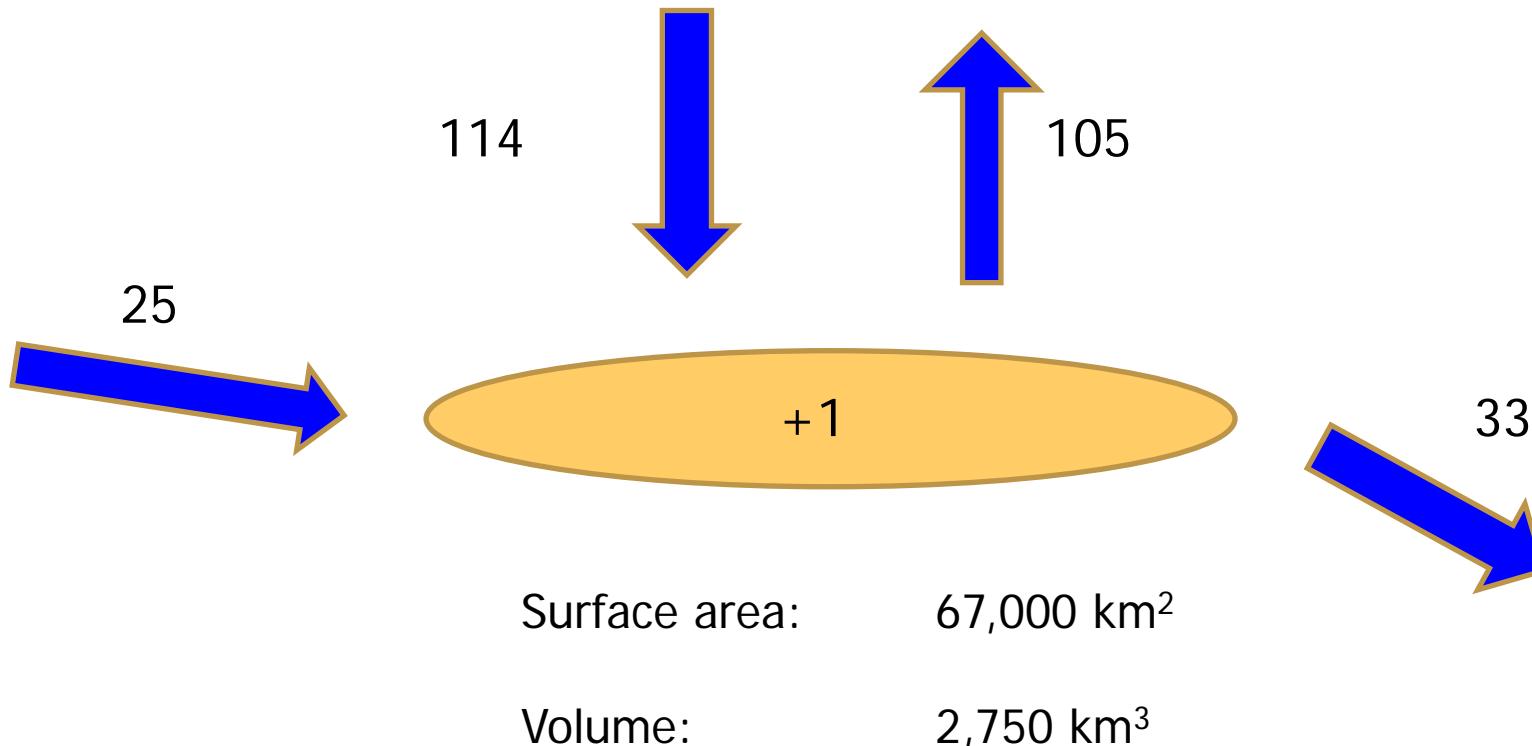
(LVBCS, 2012)



Is hydrology a natural science?

Lake Victoria

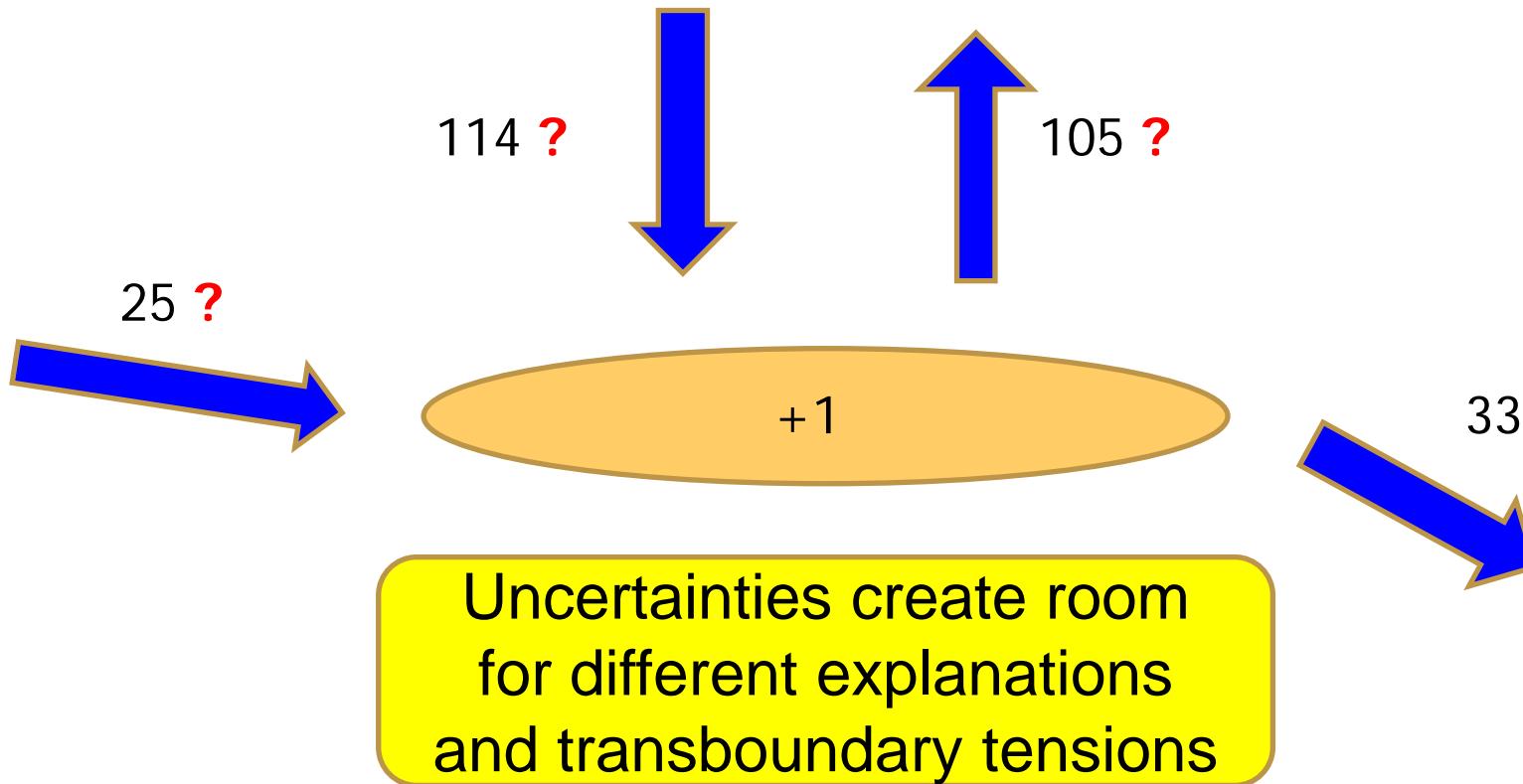
Water balance 1950-2000
(km³/yr)



Source: adapted from LVEMP I Hydrology and Meteorology Report (2005)

Lake Victoria

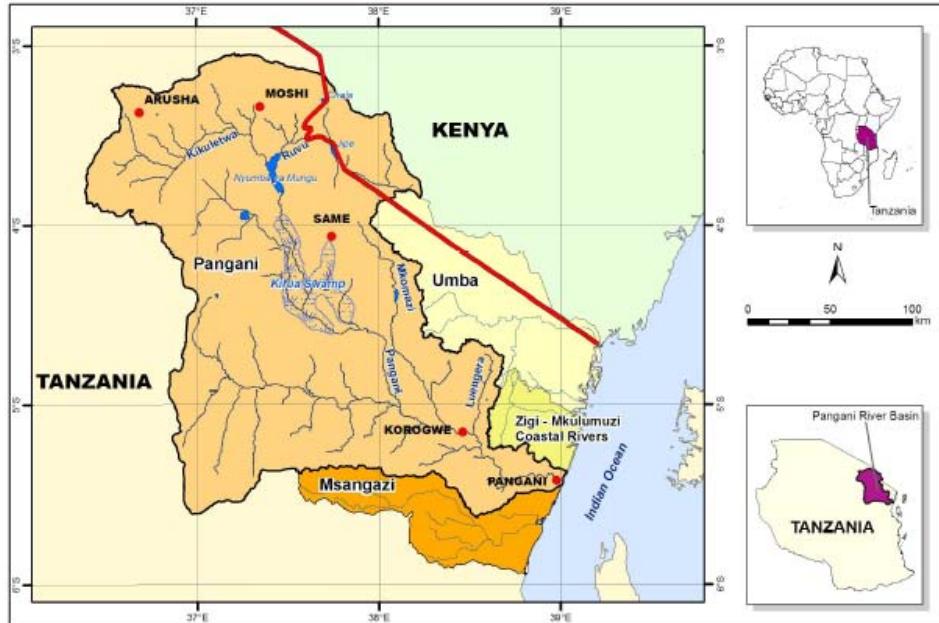
Water balance 1950-2000
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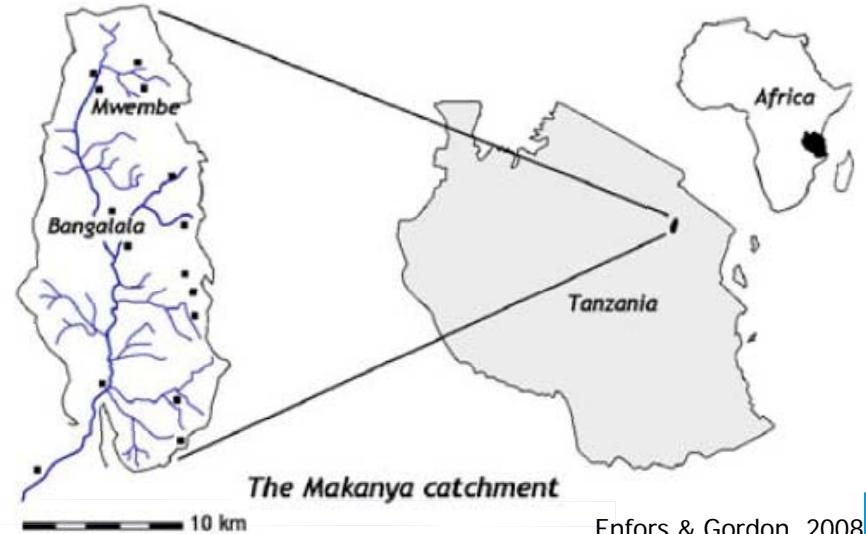
Is hydrology a natural science?

Makanya

Irrigation canals in the
Pangani basin, Tanzania



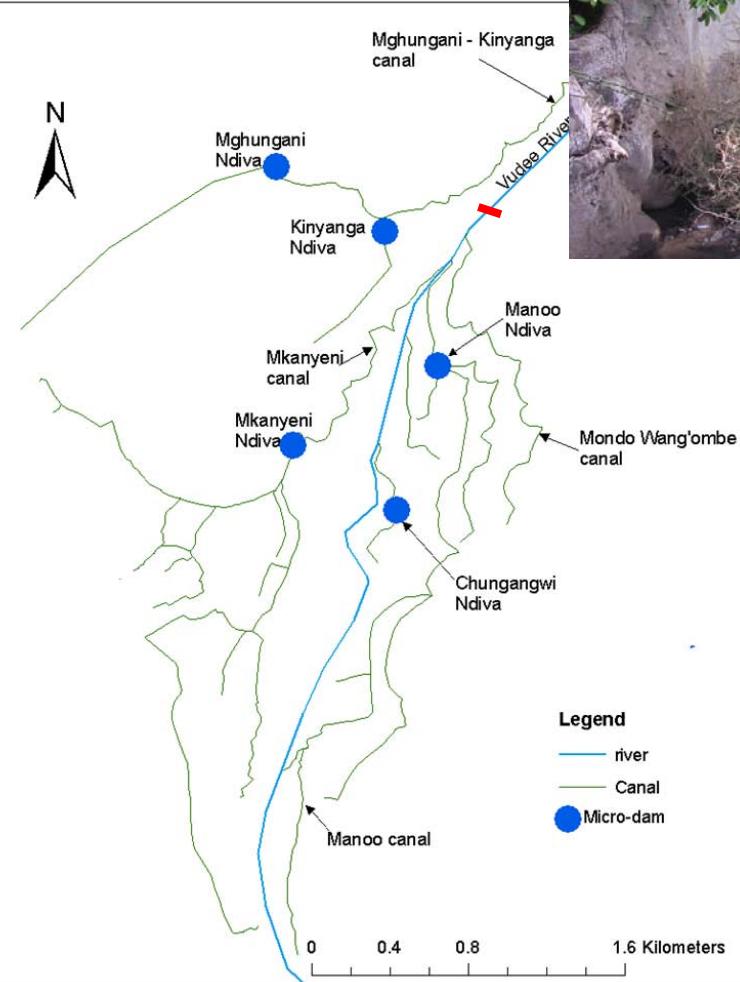
Source: PWBO/IUCN, 2008



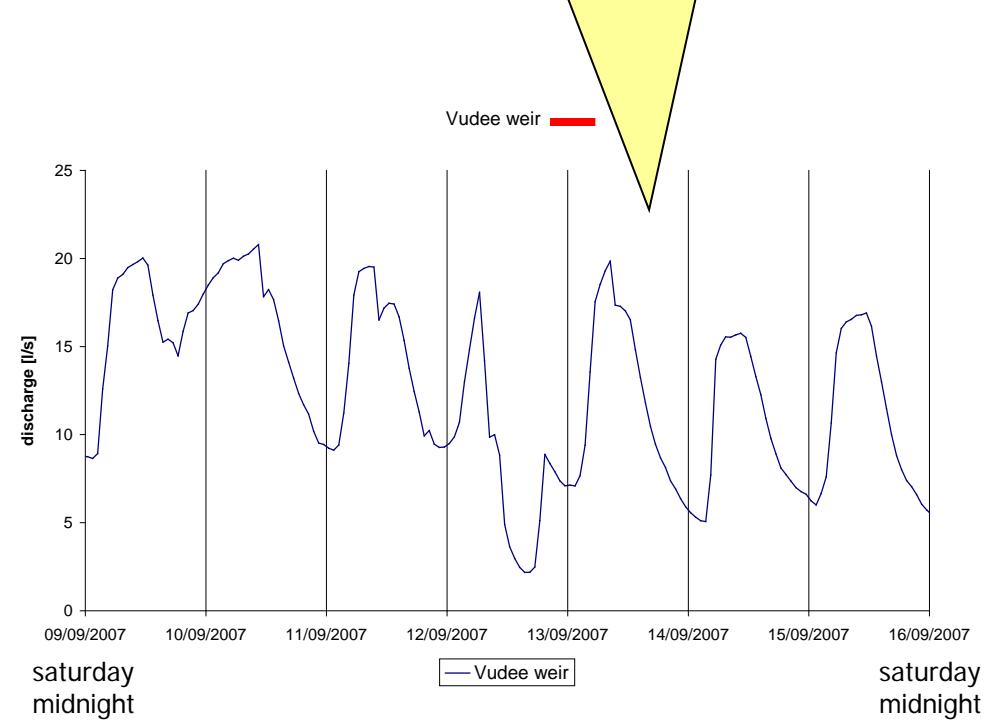
Enfors & Gordon, 2008



Makanya



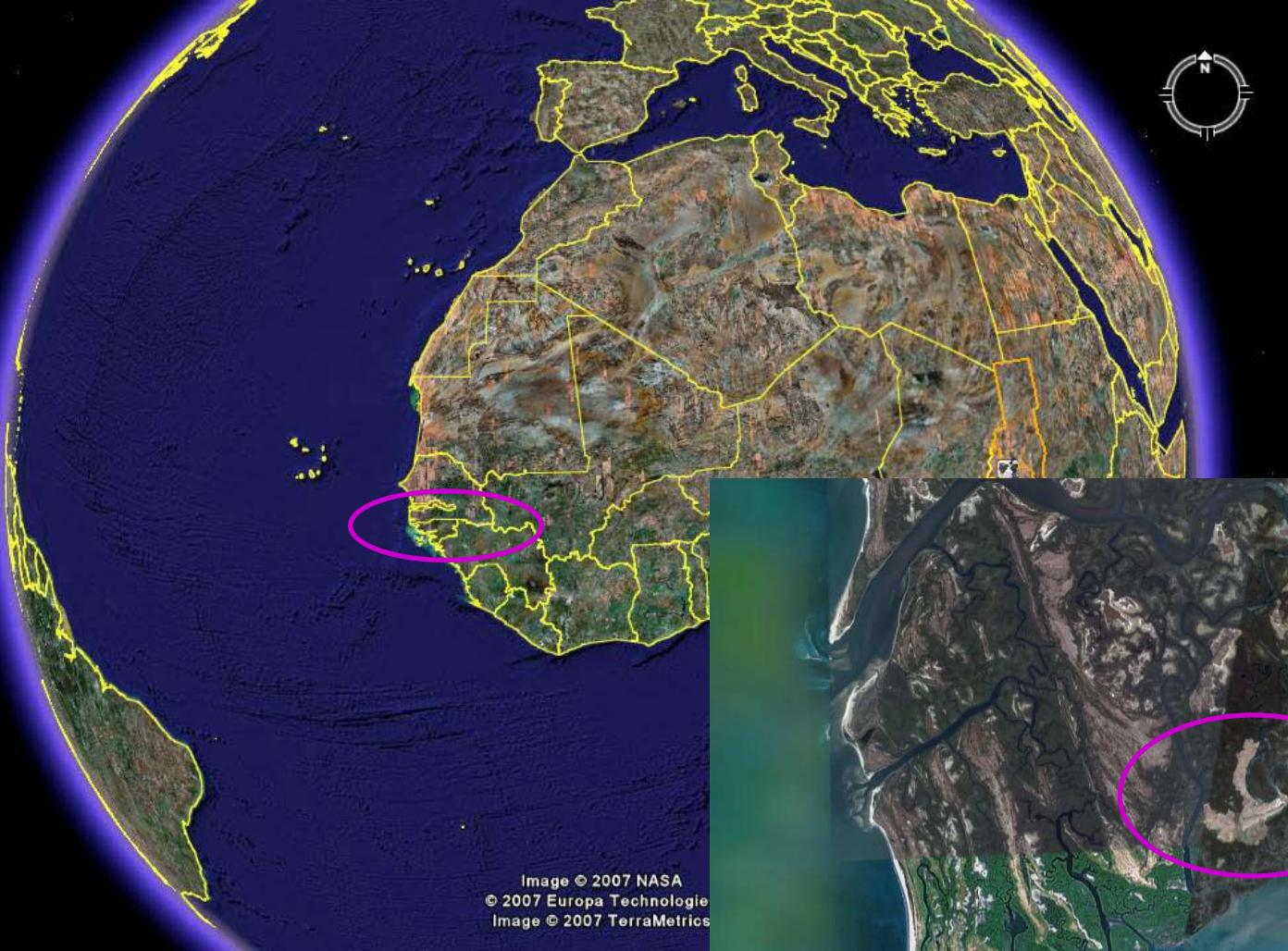
Evidence of the presence of a river institution



Komakech et al., 2012

Mul et al., 2010

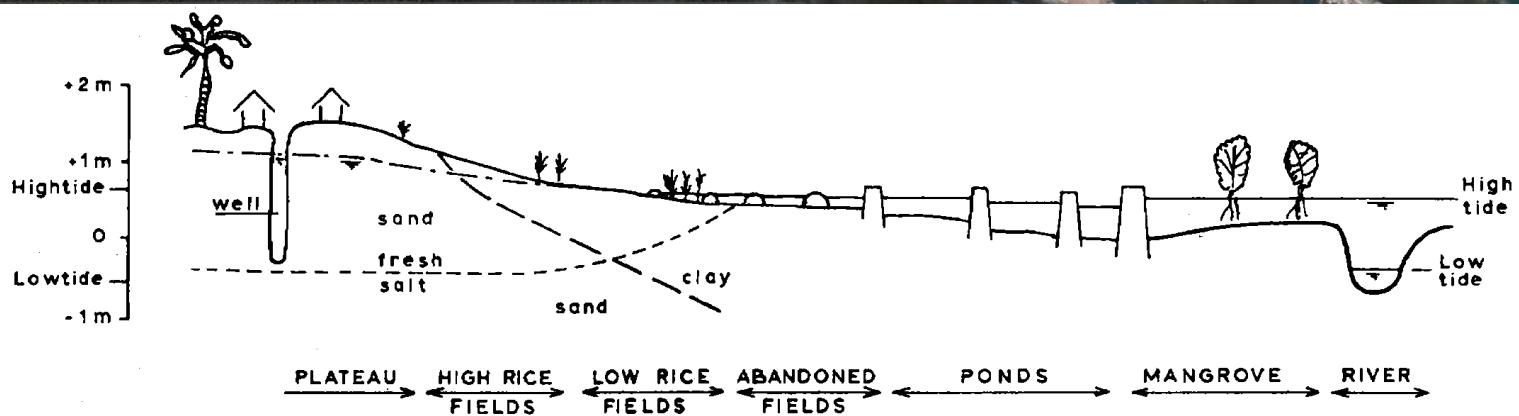
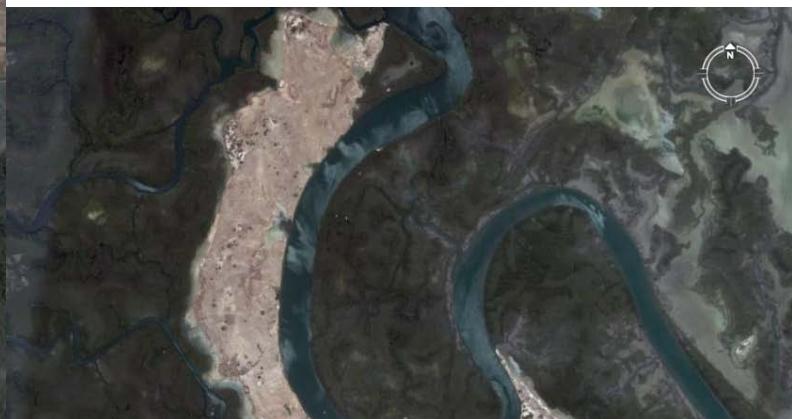




Rice polders in Basse Casamance

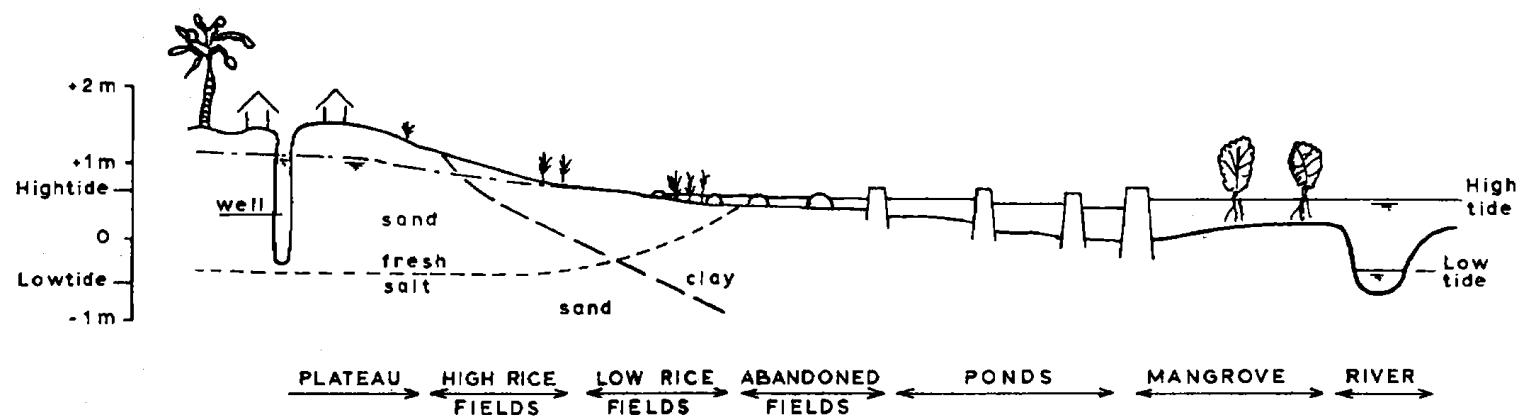








A sophisticated coupled system!



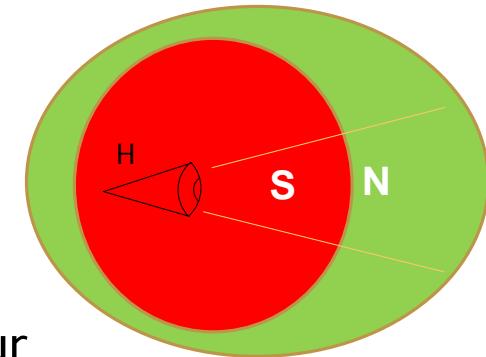
4 Towards a new (reflexive?) hydrology (i)

Everywhere and throughout history we have with limited knowledge intervened in the water cycle. As a consequence societies could develop. But nature always "*talks back*", requiring us to refine our water knowledge and adjust our interventions.

Water management is dialectic, "in which each successful response gives rise to new challenges" (Briscoe, 2010)

This dynamic may be a kind of "**double hermeneutics**":
"The 'findings' of the ... sciences (may) ... enter constitutively into the world they describe" (Giddens, 1987: 20).

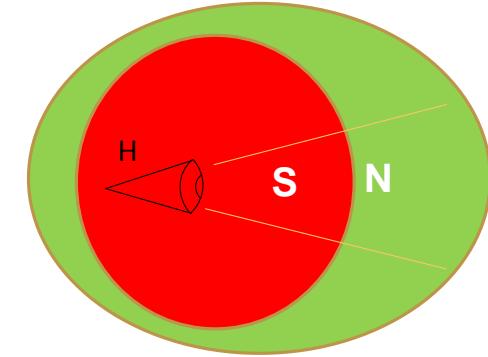
Active feedbacks and increasing levels of self-consciousness are thus an essential feature of the anthropocene.



4 Towards a new (reflexive?) hydrology (ii)

A new hydrology:

- coupled systems co-evolve
- describes and analyses how water knowledge is created and used by humans
- how it informs policies but also the behaviour of individuals
- feedbacks to the water system and the hydrology



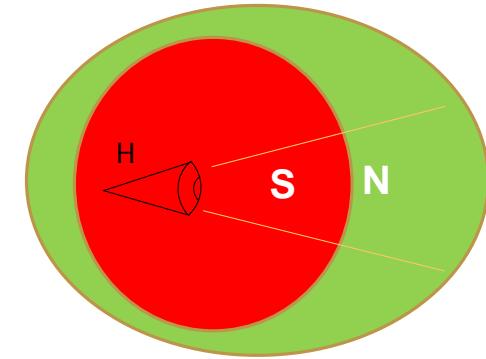
Optimality: in coupled human-water systems optimality may be a *normative* concept, difficult to “universalise”, and raising ethical issues

Co-evolution: in coupled human-water systems co-evolution leads to increased awareness among humans of their interdependence;

- co-evolution implies *learning*
- an enhanced understanding of *risk* (cf. risk society, Ulrich Beck)

4 Towards a new (reflexive?) hydrology (iii)

We need social science concepts to enrich this new hydrology, and we need hydrological concepts to enrich sociology and human geography.



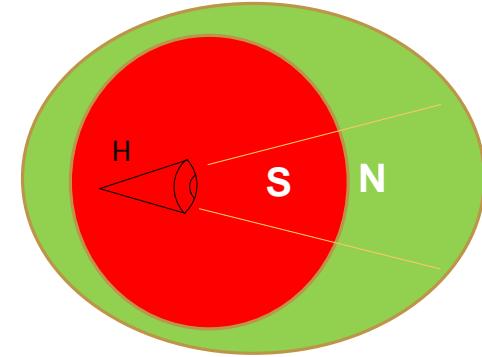
Possible starting points to overcome the rift between the natural and social sciences:

- to attribute (or allow) agency not only to humans but also to non-humans, i.e. the concept of **symmetry** (Latour)
- to accept that coupled human-water systems consist of **tangible** and **intangible** elements that interact
- to postulate a **political/normative** objective, e.g. to strive for sustainable and socially acceptable water systems
- to embrace an empirical approach and “**action research**”

4 Towards a new (reflexive?) hydrology (iv)

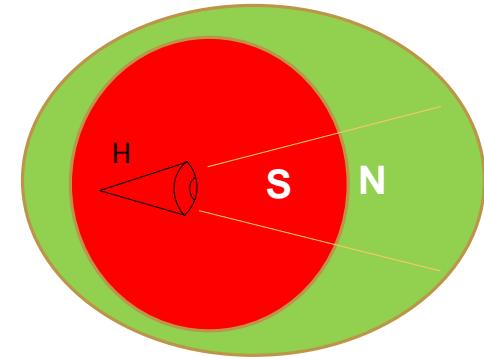
Priority research agenda
for the new hydrology:

- Densely populated floodplains
- Peri-urban / slum areas
- Spatial epidemiology of waterborne pathogens (A. Rinaldo)
- ..
- ..



Is hydrology a natural science?

So is hydrology a natural science?

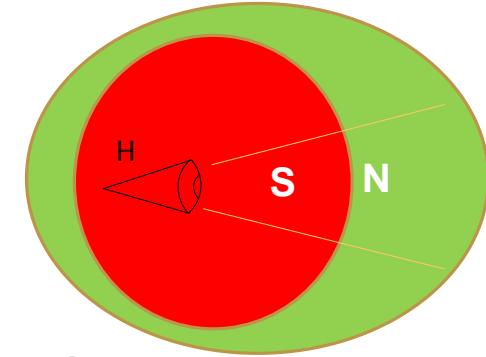


Yes, just as natural as we humans are!

Is hydrology a natural science?



*"Remember
when you speak about water
to show first the experience
and then the interpretation"*



Leonardo Da Vinci

(ca. 1500, Codex Paris H, cited in Pfister et al., 2009, p.17)